INFORMATION FROM SPACE

Satellite InSAR Data: Why We Should Care

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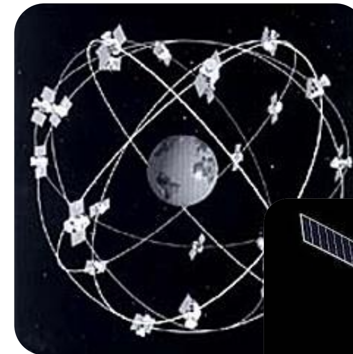
4 June 2015

TRE®
Sensing the Planet

Motivation



Fact:

- **1978**
  - first GPS satellite (Navstar-1)
  - first satellite SAR mission (SEASAT mission)

- **2014**
  - global market of GPS(GNSS) services > 1 B$
  - global market of InSAR services … < 50 M$!!

- Reasons behind a slow uptake

- Why things are changing - why we should care.

Reasons behind a low uptake

1. No «sponsor»

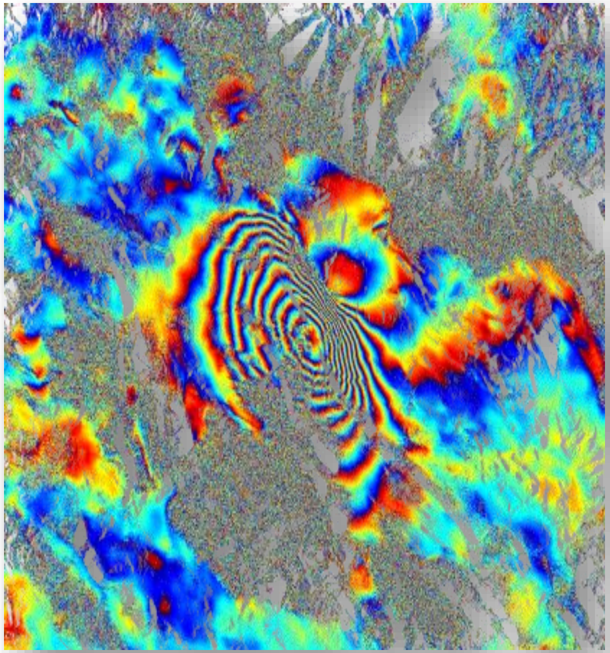
   No DoD behind InSAR..

2. The space segment:

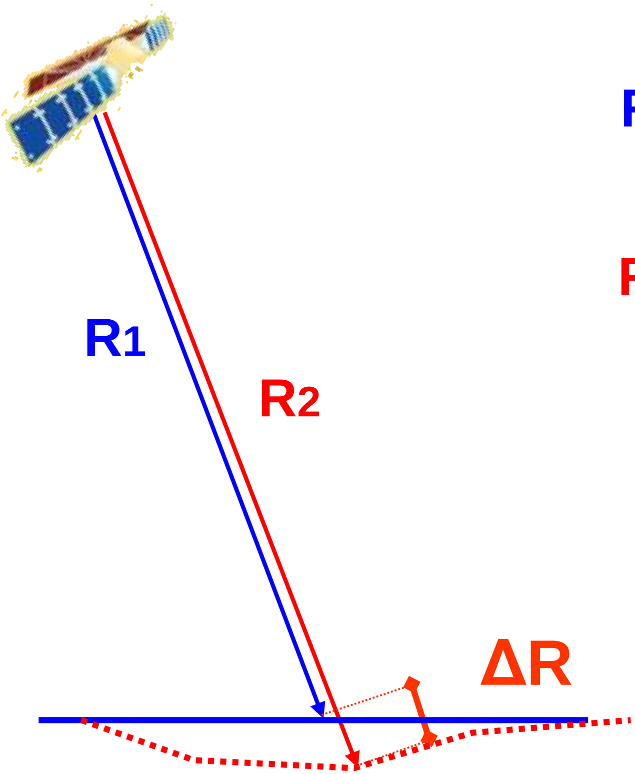
   The first InSAR results from SEASAT were a somewhat unexpected, although extremely welcome, outcome…

3. It took time to understand how to exploit the «magic» of phase values.

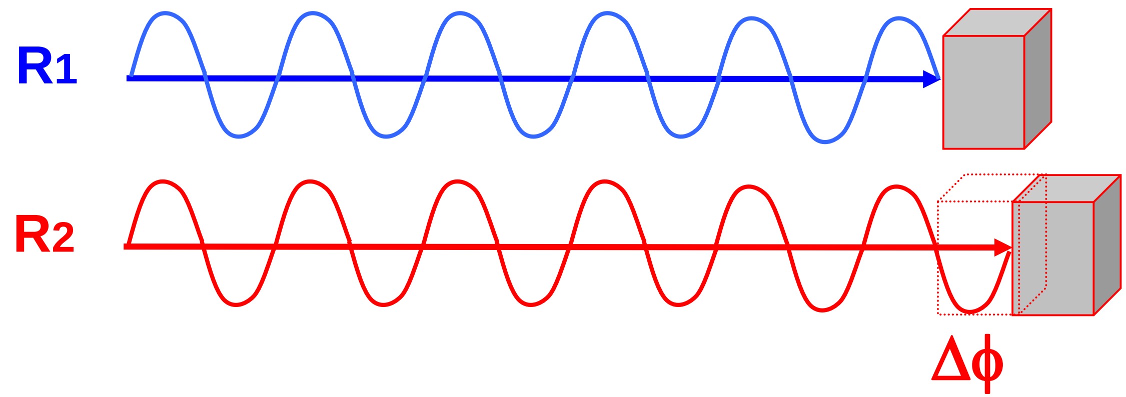
   Too much optimism at the beginning



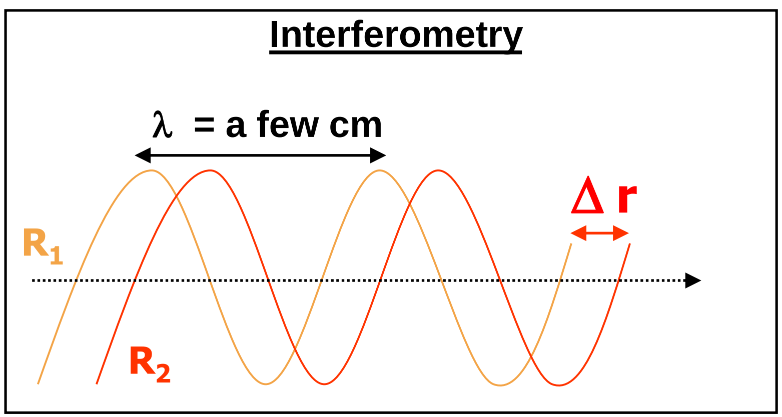
The Interferometric Concept



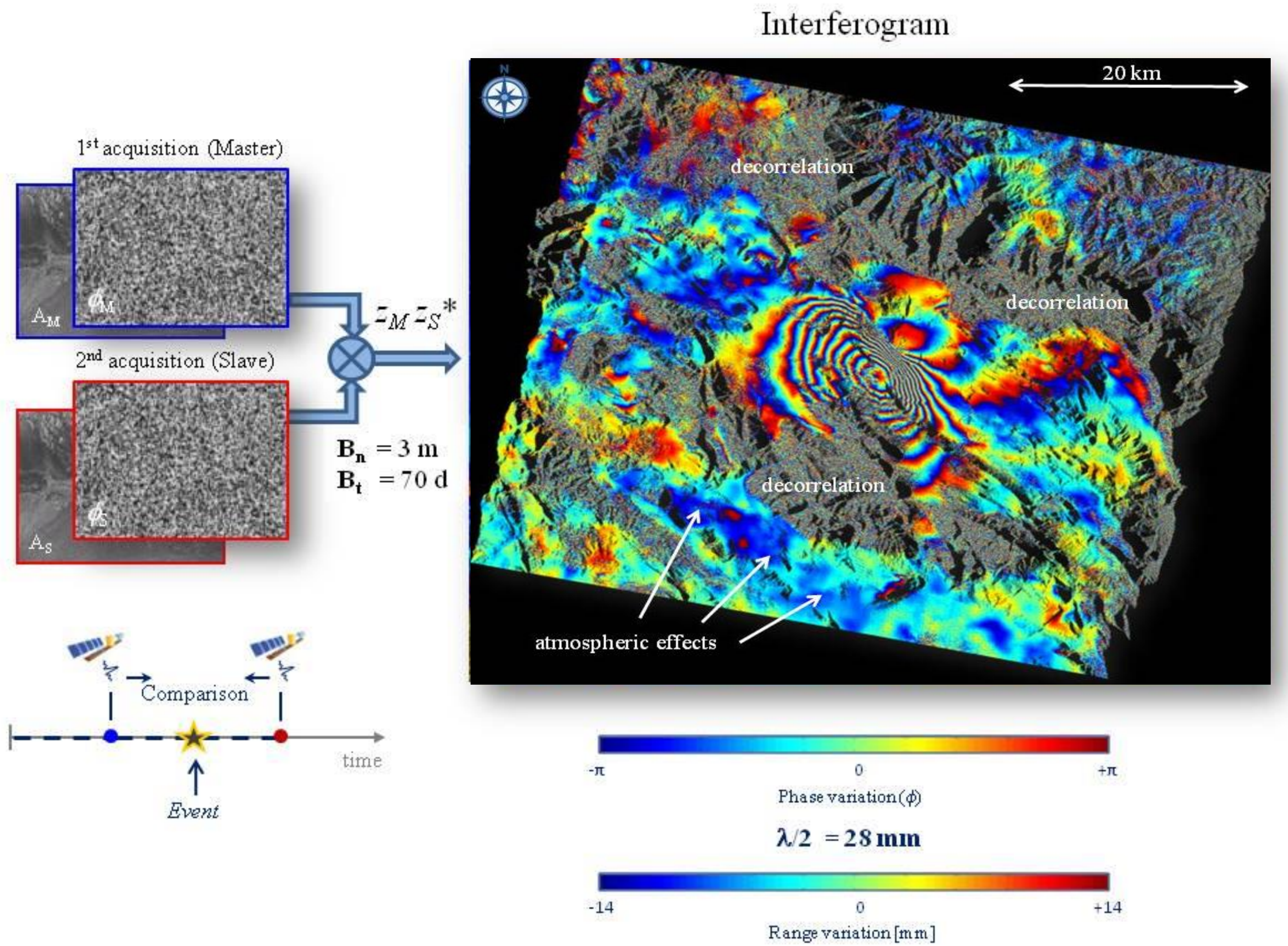
The *unit of length* used in InSAR is the wavelength:



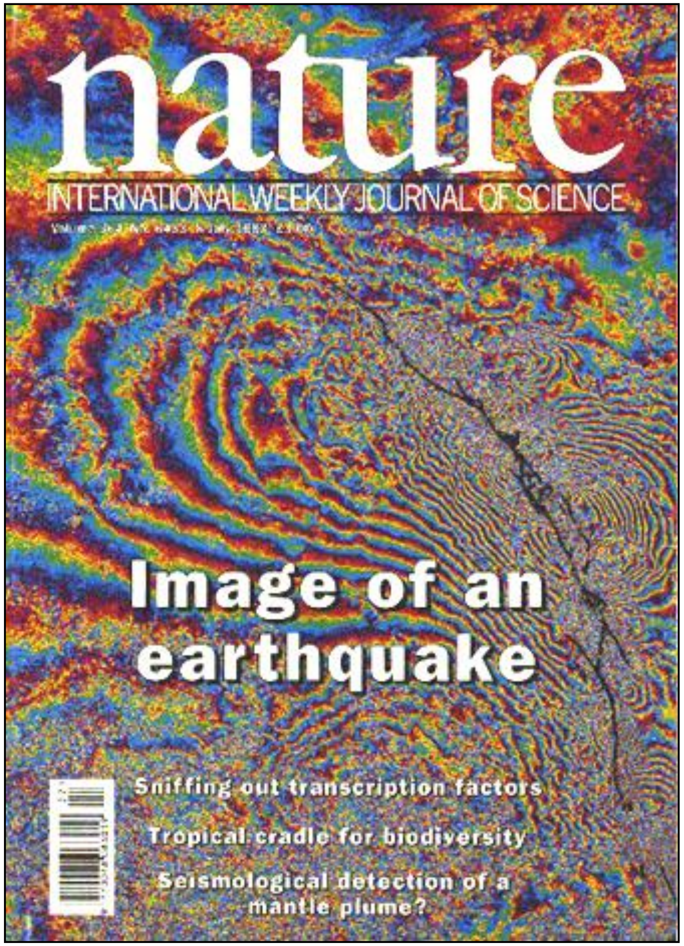
$$\Delta R = c \cdot \Delta\phi$$



SAR Interferometry



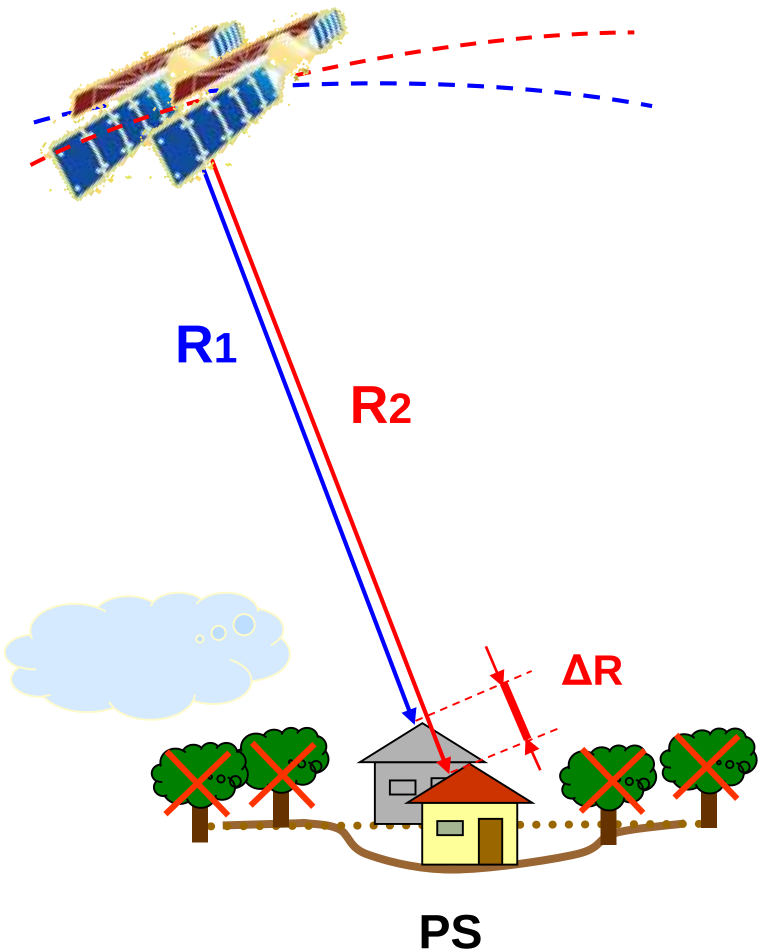
Limits of conventional InSAR analysis



Since 1992 - thanks to ESA ERS-1 archive - a growing gallery of InSAR examples started being available.

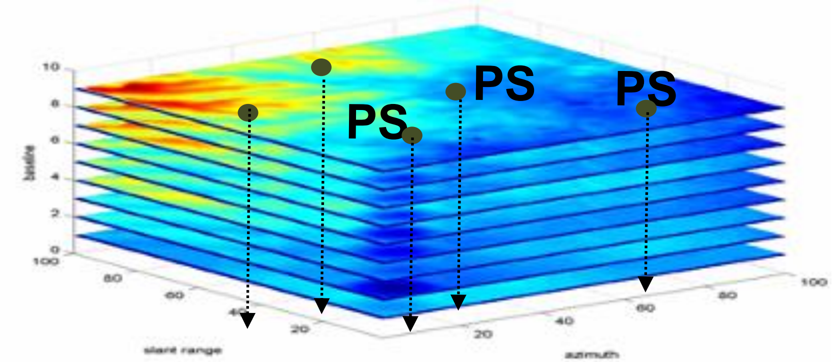
While more and more results were generated, the presence of atmospheric artefacts and problems due to phase decorrelation (temporal and/or geometrical) became more and more evident

A step forward: the PSInSAR technique



DInSAR limiting factors:

- **reflectvity changes**
- **atmospheric disturbances**



By using:

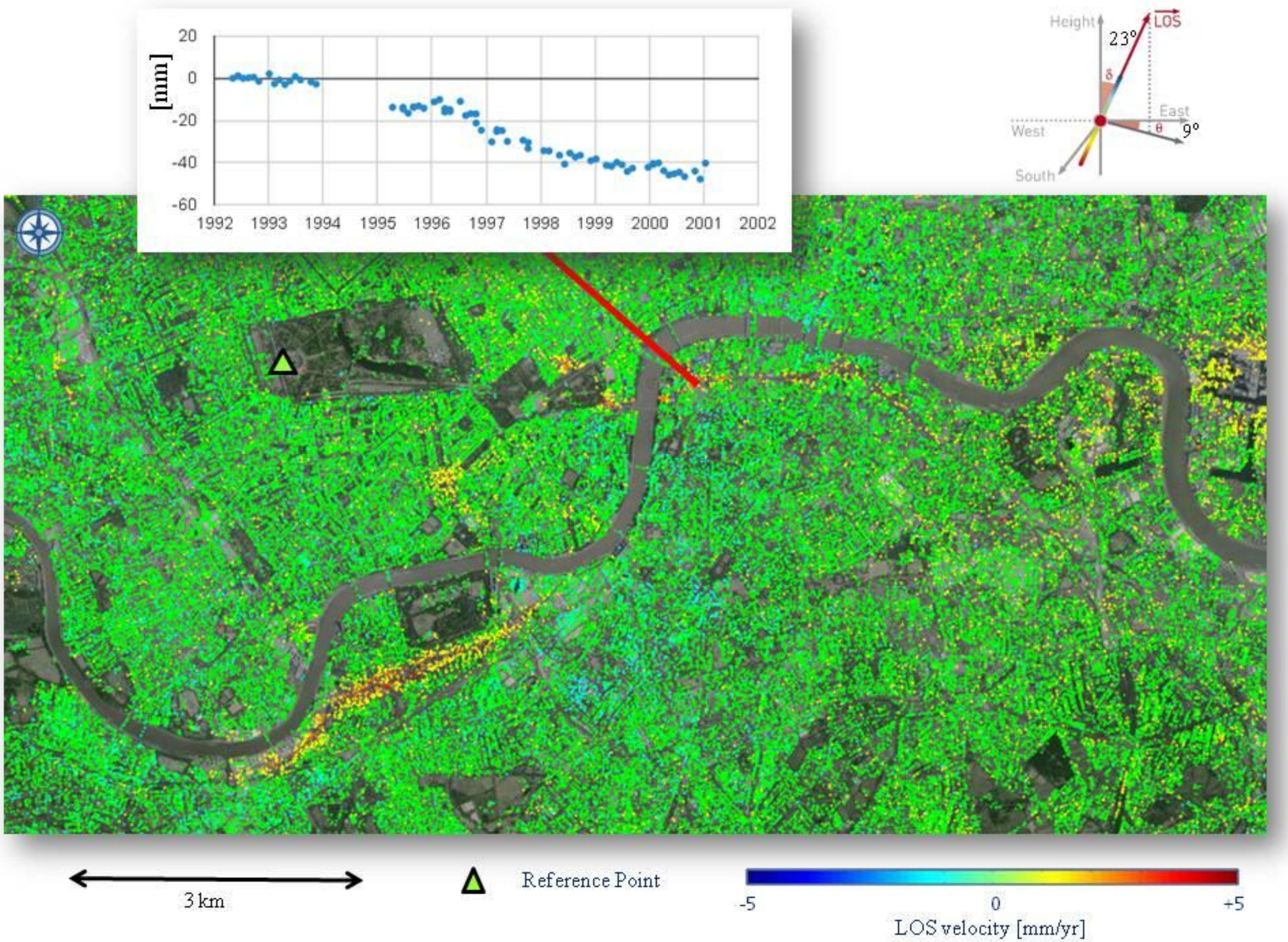
- **long temporal series of SAR data**

identification of:

- **coherent radar targets:**
  the *Permanent Scatterers (PS)*

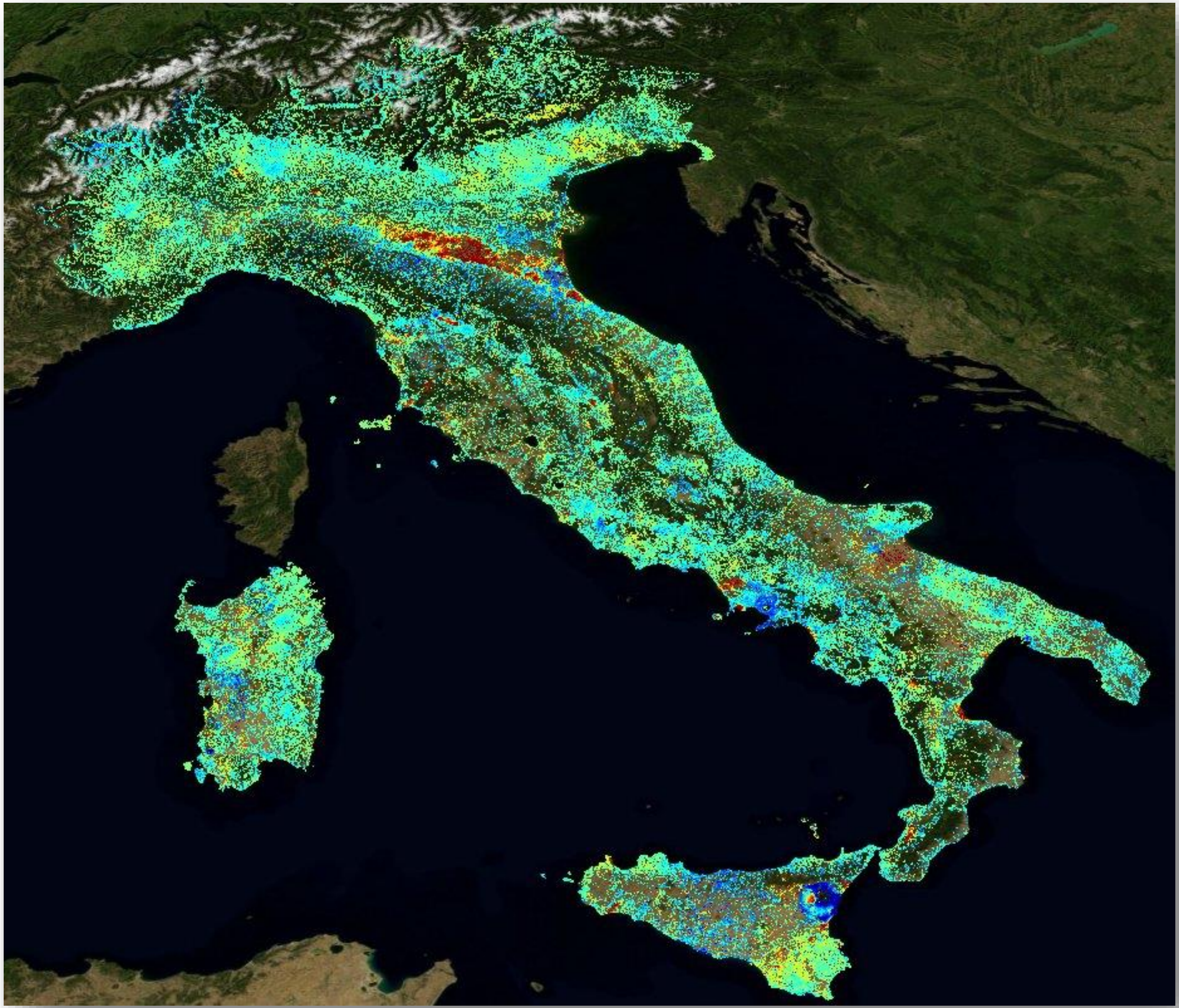
where atmospheric effects can be estimated and removed

Advanced InSAR Analysis over London



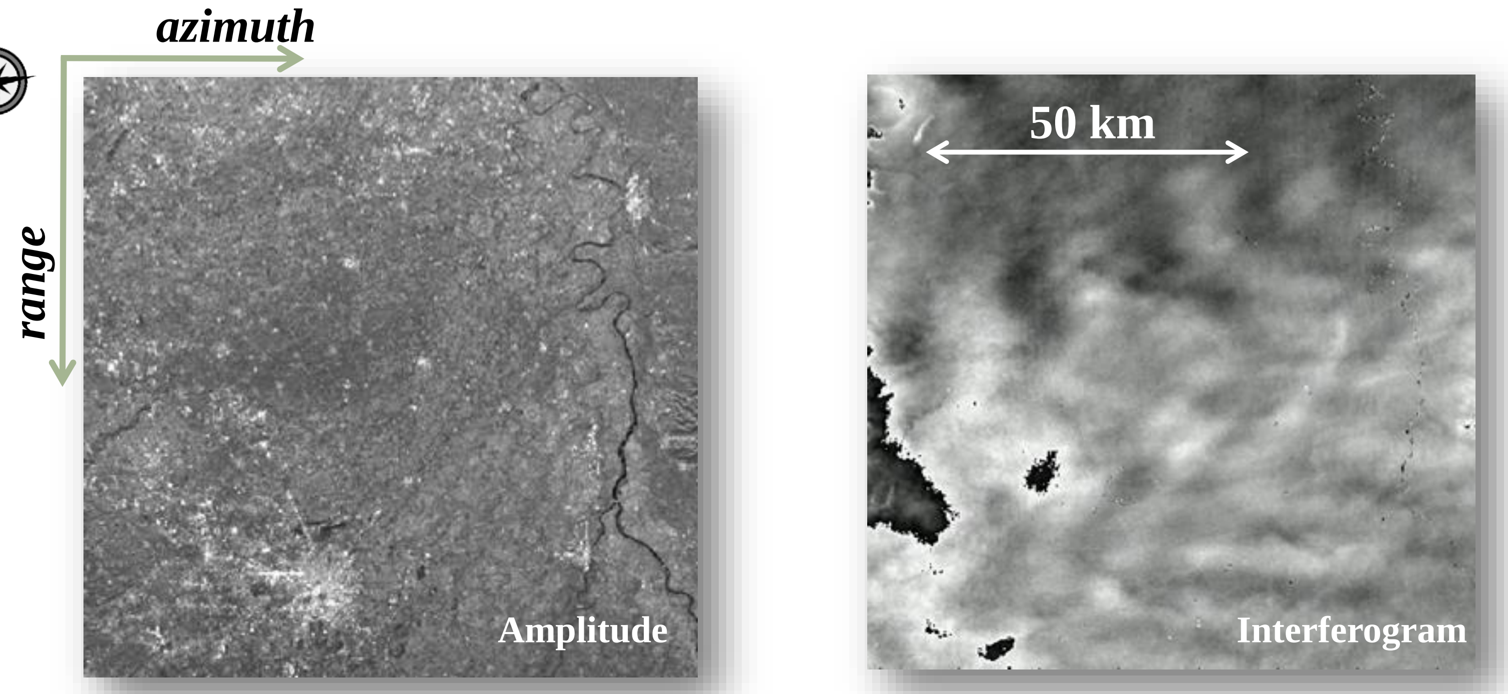
EXPERIENCE
(learning by doing..)

Large-scale applications



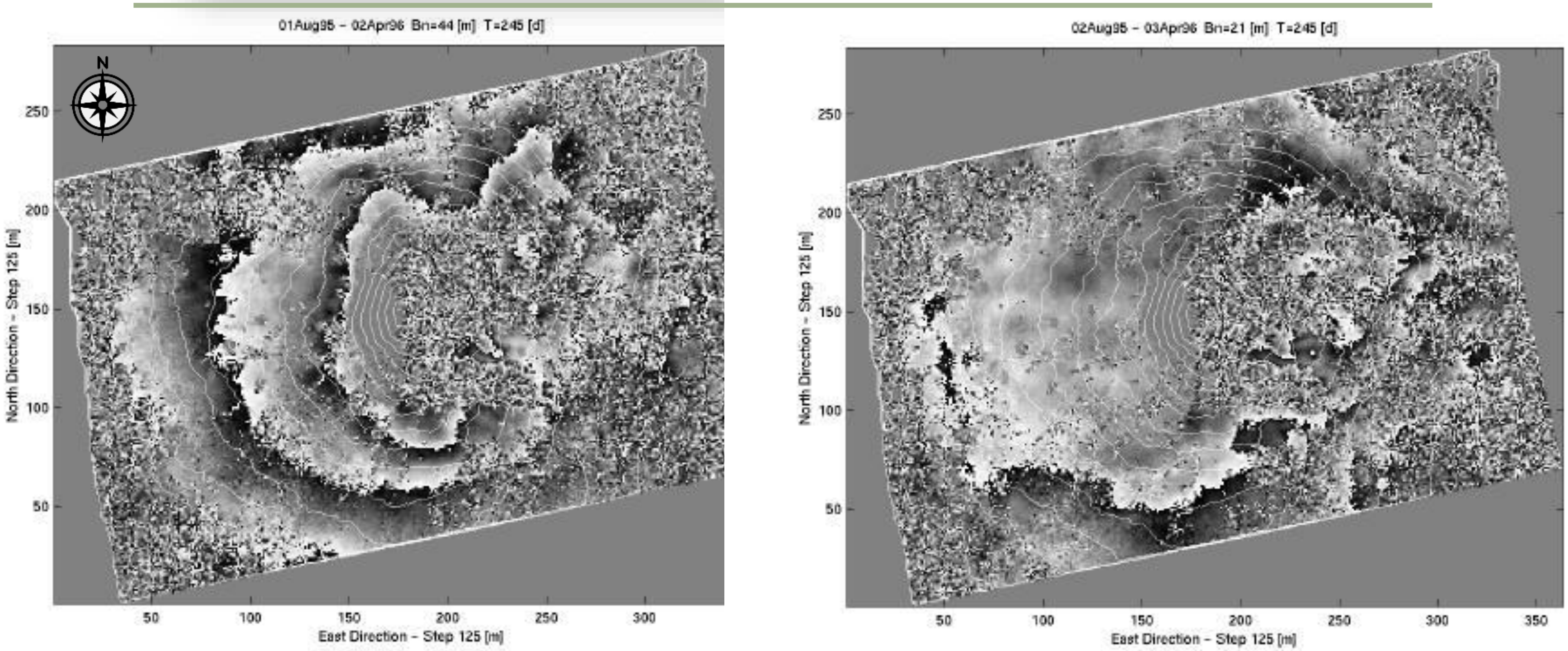
- National coverage
- 8324 ERS images
- 1652 Envisat data
- >15,000,000 PS
- 2 years for data processing
- Project financed by the Italian MoE

(a)



azimuth
range
50 km
Amplitude
Interferogram

(b)



01Aug95 - 02Apr96 Bn=44 [m] T=245 [d]
North Direction - Step 125 [m]
East Direction - Step 125 [m]
02Aug95 - 03Apr96 Bn=21 [m] T=245 [d]
North Direction - Step 125 [m]
East Direction - Step 125 [m]

Precision assessment

Common to differential GPS, all PS measurements are *differential* measurements with respect to a reference radar target. Accuracy depends on many factors: # of images, PS density, climatic conditions (APS power), distance from the GCP, etc

POSITIONING	**Easting**	**Northing**	**Height**
Precision (1σ)	7 m	2 m	1,5 m

LOS Displacement	**Average Displacement Rate**	**Single Measurement**
Precision (1σ)	<1 mm/yr	<4 mm

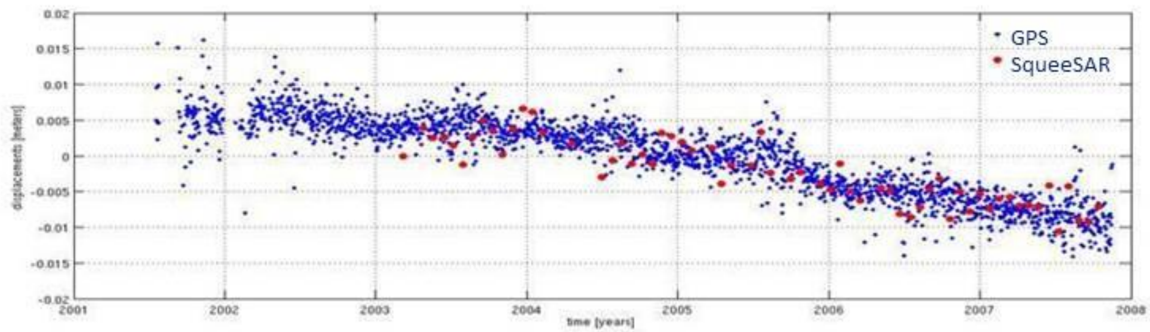
Typical values for C-band data @ < 4 km from the reference point

Validation

GPS

- GPS
- InSAR

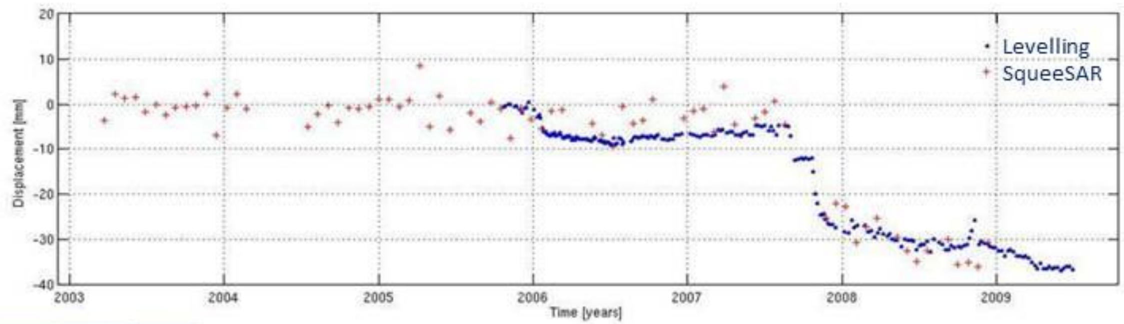
(a)



Optical levelling

- Levelling
- InSAR

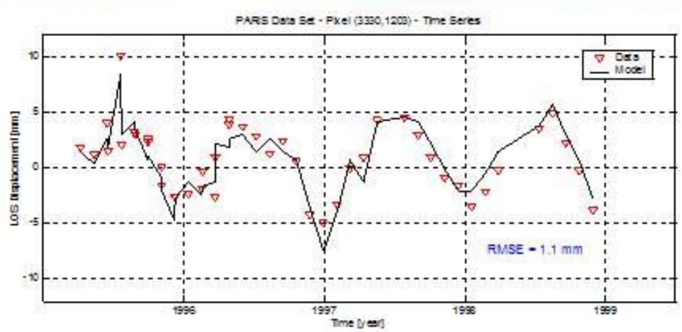
(b)



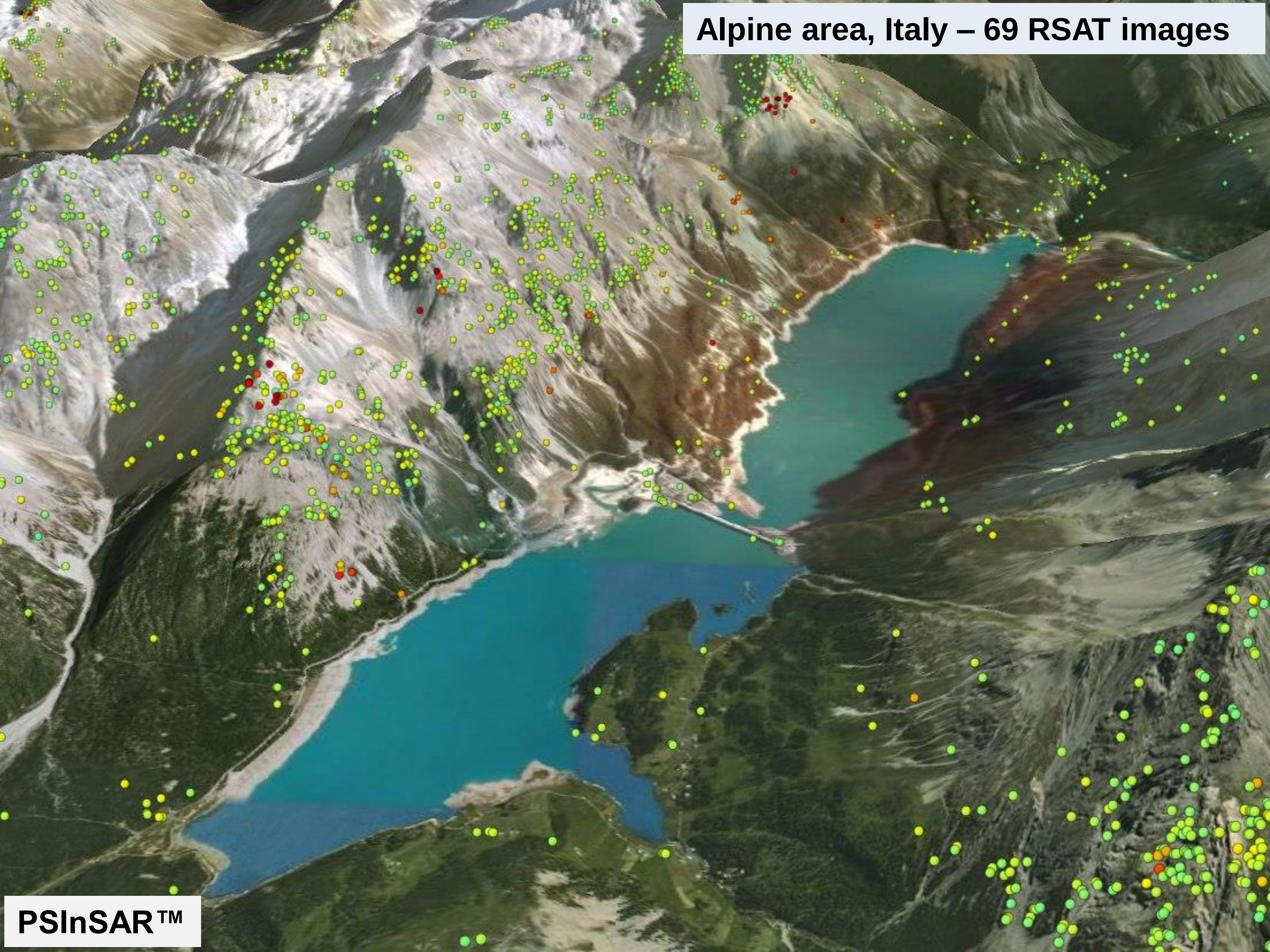
Thermal Dilation

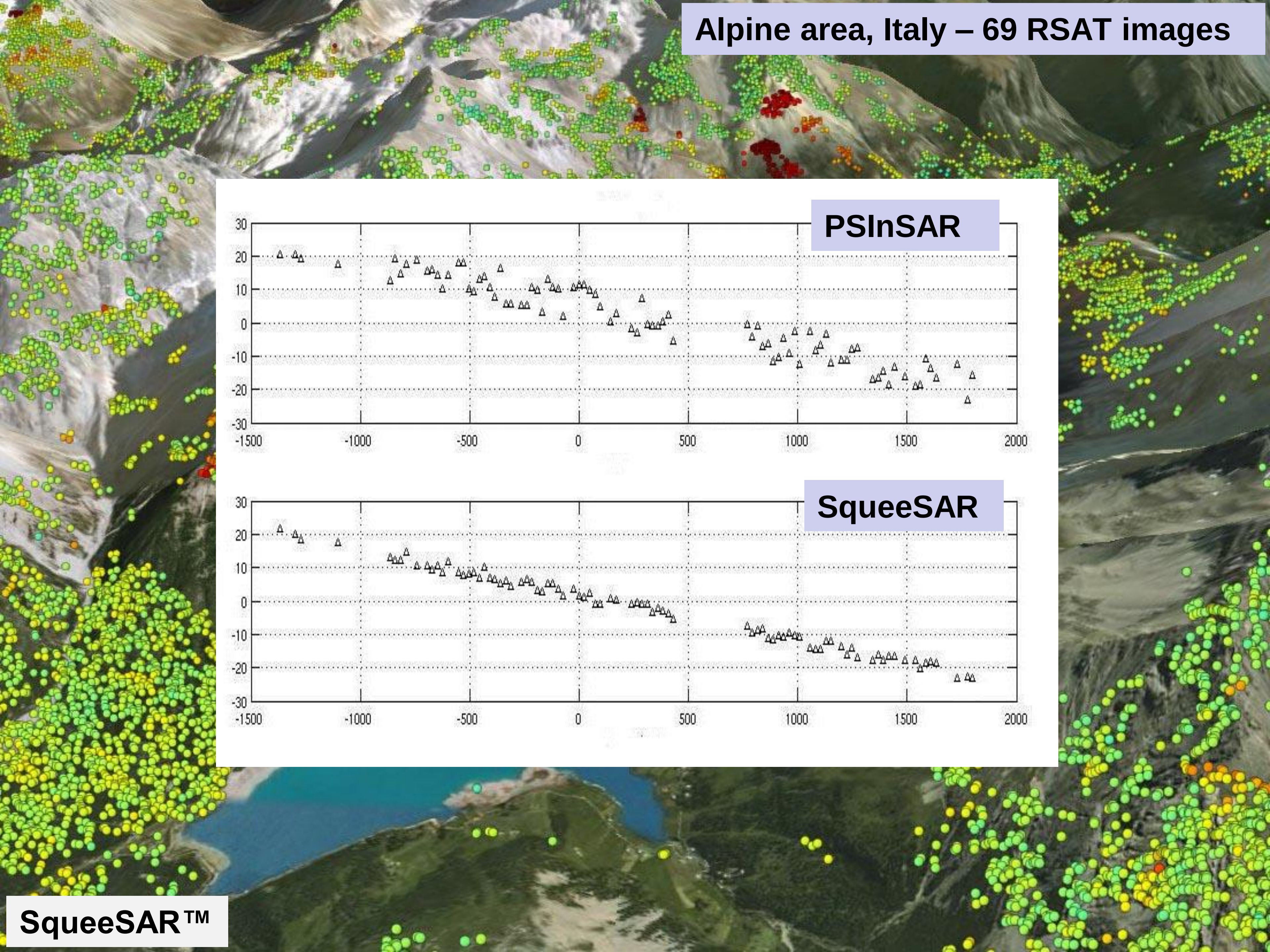
- Thermal Dilation Model
- InSAR

(c)



Alpine area, Italy – 69 RSAT images

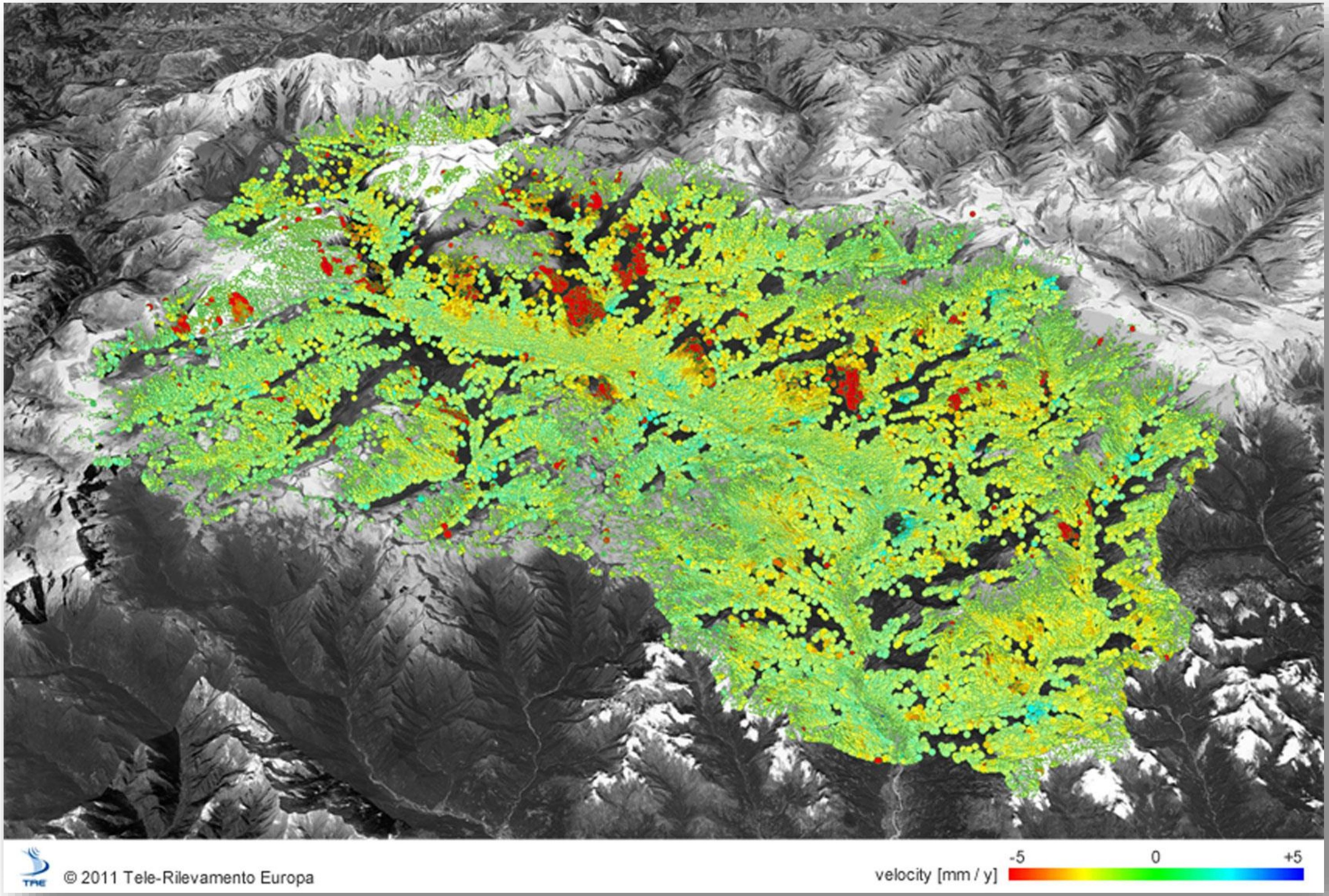




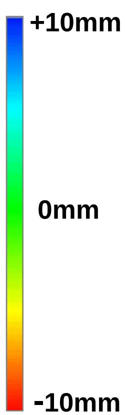
Alpine area, Italy – 69 RSAT images
PSInSAR
30
20
10
0
-10
-20
-30
-1500
-1000
-500
0
500
1000
1500
2000
SqueeSAR
30
20
10
0
-10
-20
-30
-1500
-1000
-500
0
500
1000
1500
2000
SqueeSAR™

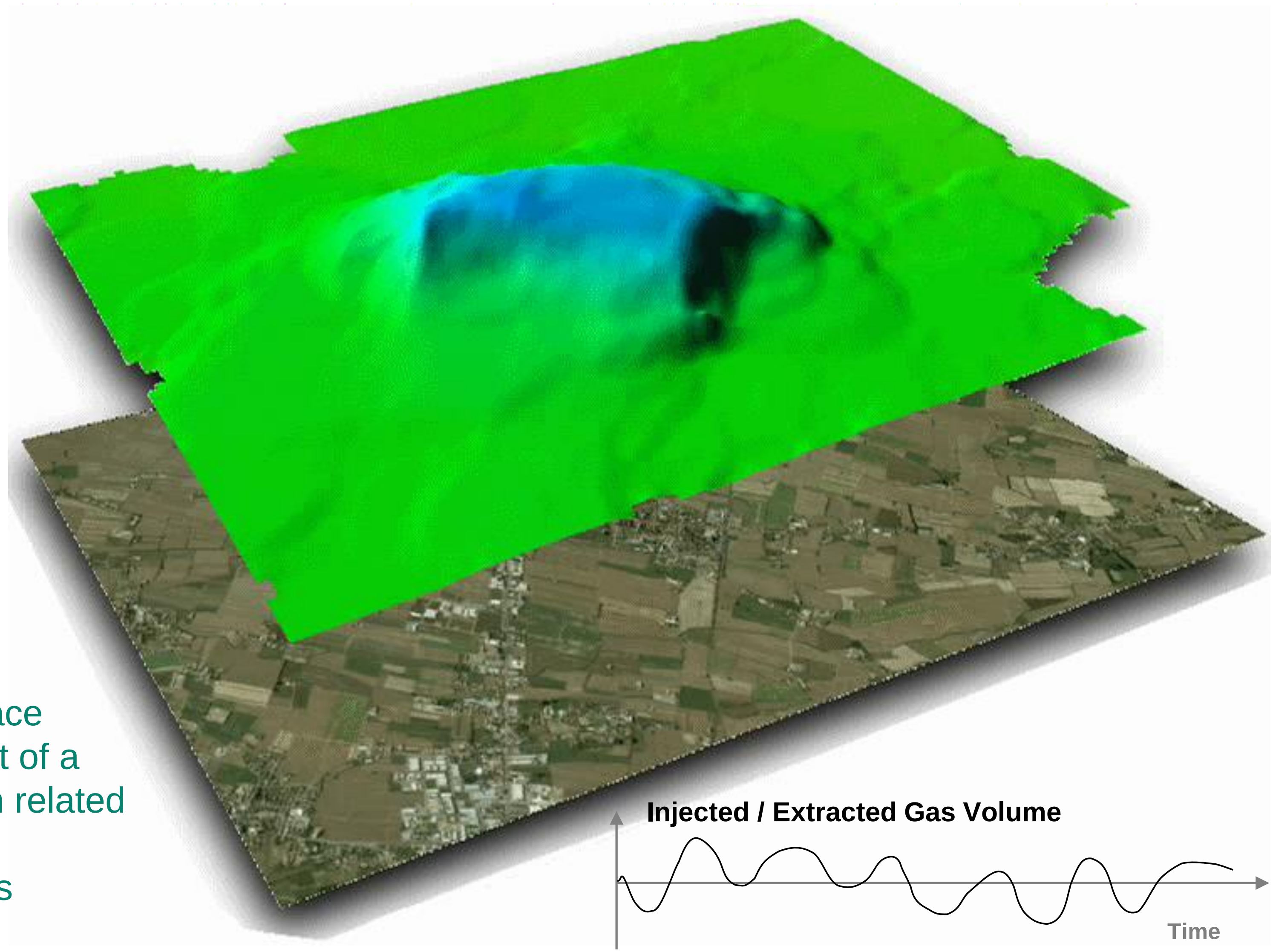
Applications where InSAR is becoming a «must»

Regional InSAR Analysis



Underground Gas Storage (UGS)

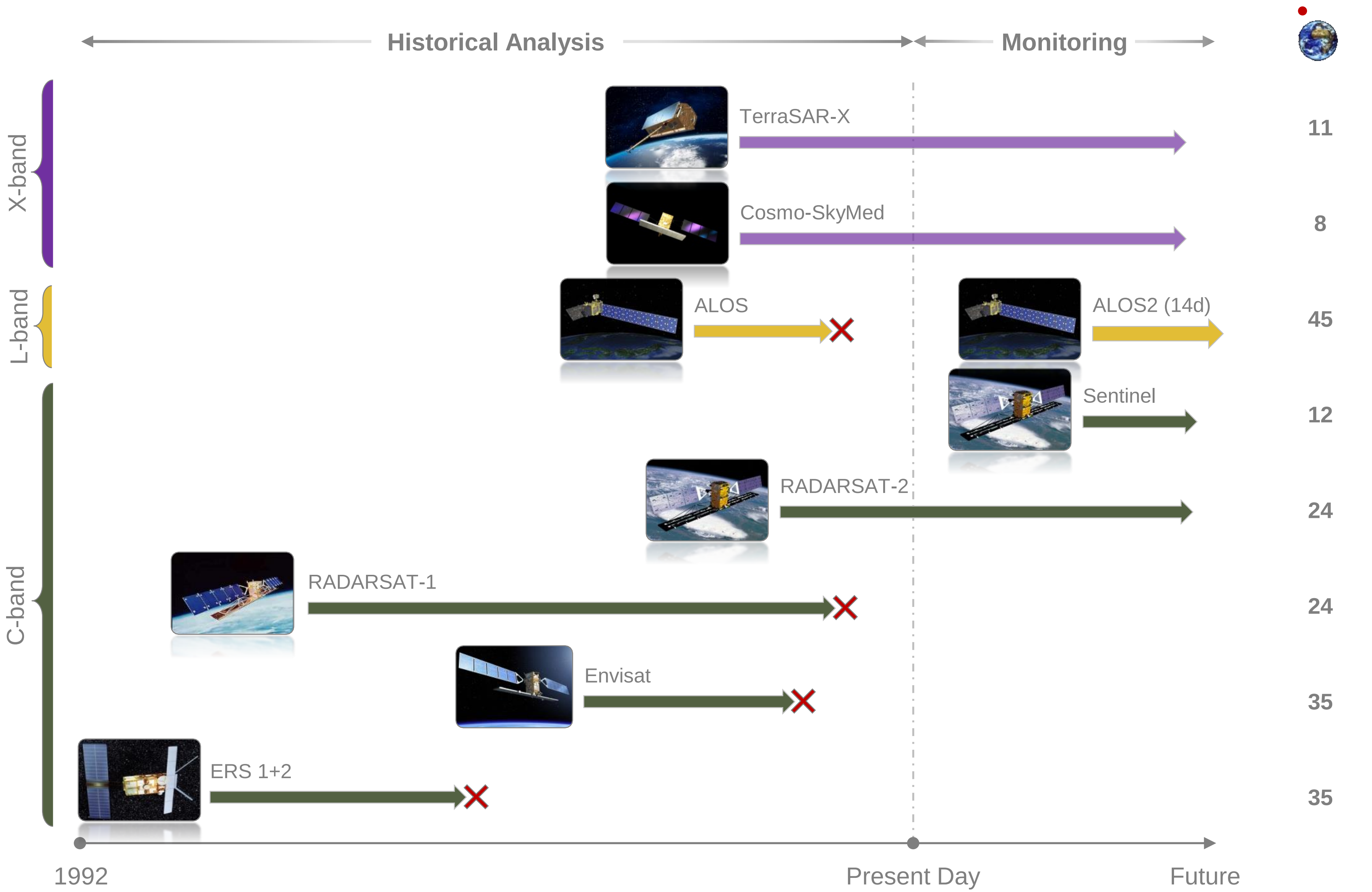




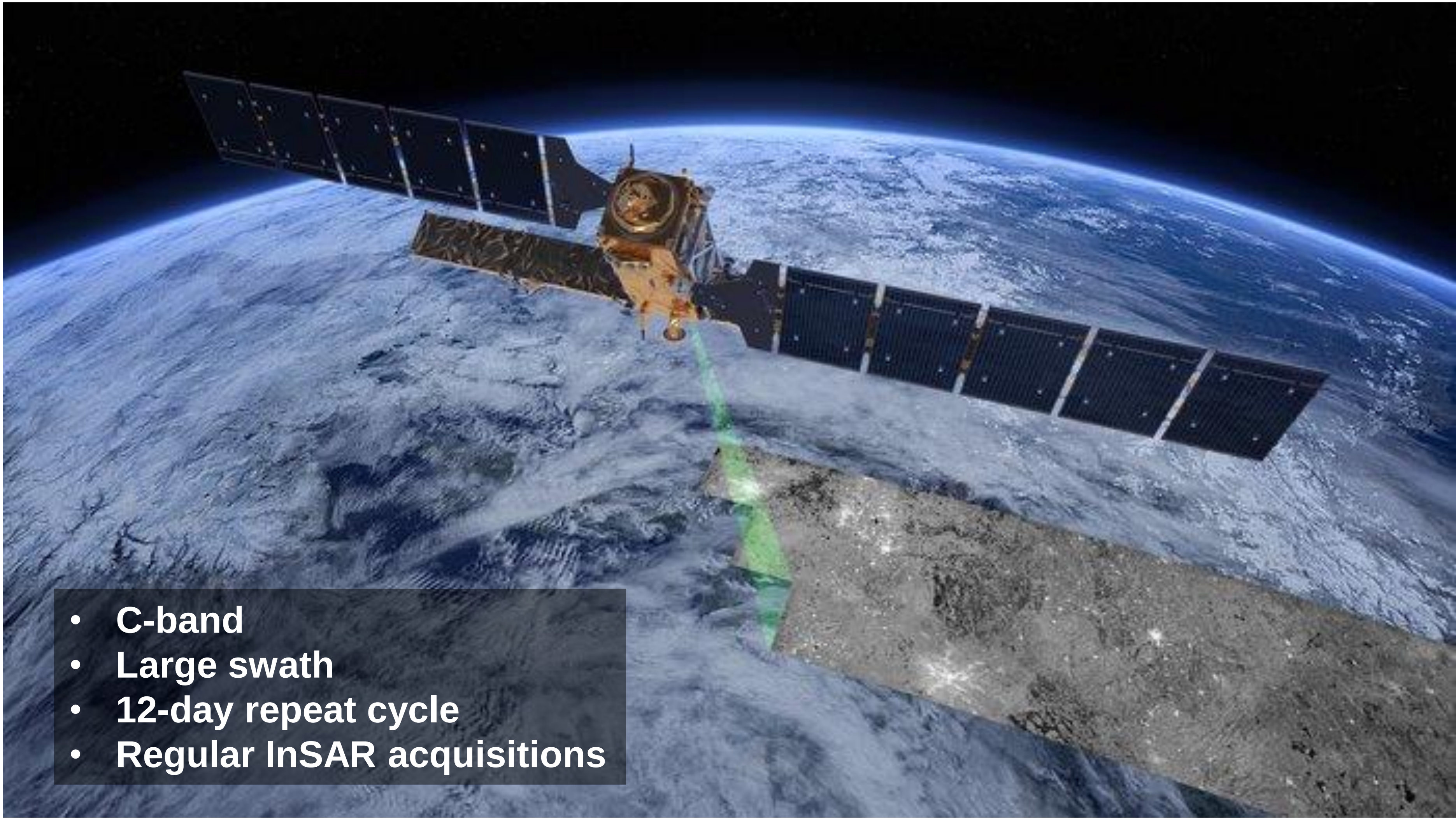
Vertical surface displacement of a gas field with related injected and extracted gas volumes

Space Segment

SAR Satellites



Sentinel-1A: The «Game Changer»



- C-band
- Large swath
- 12-day repeat cycle
- Regular InSAR acquisitions

Conclusions

Strenghts and weaknesses

Strenghts	Weaknesses
InSAR data can provide a synoptic view of displacement phenomena over <u>large areas</u>	Vegetation and snow are both severe limitations for InSAR measurements
Data are sensitive to mm displacement and precision has been steadily improved by the latest algorithms	Fast motion difficult to measure (since it can create phase decorrelation and/or phase aliasing)
Possibility to retrieve surface deformation data since 1992, by taking advantage of historical SAR archives	3d displacement vectors cannot be estimated with the same accuracy along the three directions
The number of satellite data sources is increasing. Sentinel-1A and 1B will be a "game changer"	Temporal frequency of the acquisitions limited by the satellite repeat cycle
No need to install anything on ground (at least in non vegetated areas)	Difficult to estimate the locations of measurement points over a certain AOI before processing a data set

Suggestions

- InSAR data can be used successfully to select the best locations for *in situ* instrumentations and geodetic benchmarks

- InSAR is complementary to GPS(GNSS) data, rather than a rival. Only by the synergy of the two technologies it is possible to design effective monitoring systems

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